

## Dynamic Design: Launch and Propulsion

## Launching Genesis: Propulsion

### STUDENT ACTIVITY

#### BACKGROUND INFORMATION

There are two types of propulsion involved in the launch and subsequent trip to [L1](#). The first type of propulsion is the launch of the Genesis spacecraft aboard the Delta II rocket. This propulsion lifts the spacecraft beyond Earth's atmosphere. Once the spacecraft is launched, trajectory corrections must be completed to ensure the spacecraft will reach L1. The propulsion subsystem is made up of eight 1 Newton thrusters and two 22 Newton thrusters that will be used for the corrections.

In the first part of this activity you will model the Delta II rocket by using a balloon to launch a Ping-Pong ball to the ceiling of the classroom. In the second part of this activity you will model the thrusters used to course corrections on the spacecraft using a milk carton and water. In the third part of this activity you will investigate how the size of the exit nozzle affects the force of a thruster.

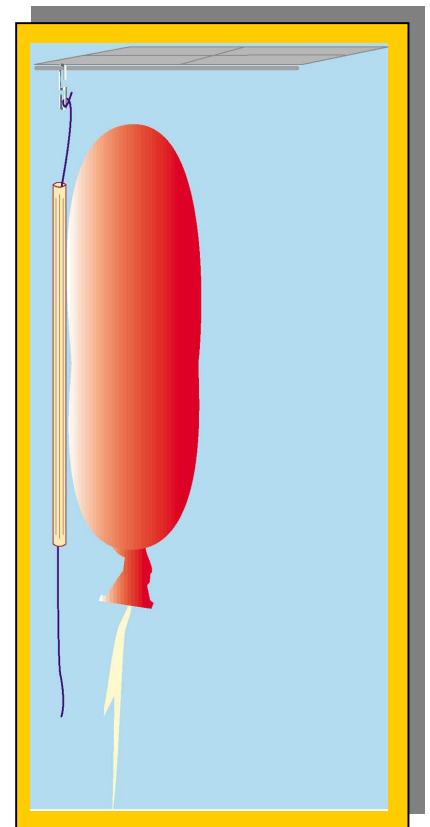
#### PROCEDURE

##### Part 1: Launch

1. Attach fishing line to the ceiling by taping the line onto a ceiling tile or attaching a bent paperclip to the ceiling tile brace. Allow the fishing line to touch the floor.
2. Blow up the balloon and hold it closed with a clothespin.
3. Use the small paper cup as a payload bay to carry the spacecraft. In this simulation the spacecraft will be a Ping-Pong ball. Place the Ping-Pong ball in the paper cup and invert it so that the ball is in your hand. Place the cup with the Ping-Pong ball on the balloon so that the ball is setting on the balloon. Secure the cup to the balloon using tape.
4. Attach the straw to the side of the balloon so that it is perpendicular to the ground. Thread the fishing line through the straw. Have one person hold the line taut and another person release the clothespin. Observe what happens to the Ping-Pong ball.
5. If the ball made it to the ceiling, proceed to part two. If it did not, redesign your rocket balloon and repeat until it successfully touches the ceiling.

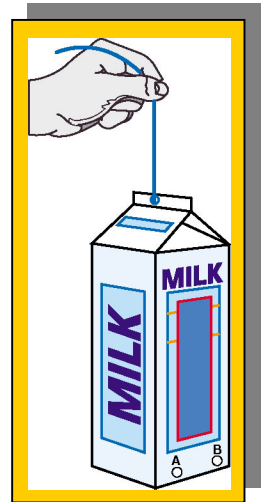
##### Part 2: Propulsion

1. (Optional) Read the Teacher Text "[Propulsion](#)." This text describes various past, present, and future propulsion systems, including a description of the propulsion used for Genesis.
2. In this section, you will use a milk carton with holes in the side to simulate the locations of the thrusters on the Genesis spacecraft. The milk carton represents the propulsion subsystem on the Genesis spacecraft. The holes represent the locations of the 1 Newton thrusters. The 22 Newton thruster is not illustrated in this model.





3. Use the figure at right as a guide. Use a nail to make the holes on the milk carton. The holes should all be the same size. Make two holes near the edge on one side of the milk carton. Repeat this on the opposite side of the milk carton.
4. Place pieces of tape on top of each of the holes, making sure the tape makes a good seal. Attach a string to the top center of the milk carton. Label each hole as shown in the diagram at right.
5. Fill the carton with water and while suspending the carton with the string, release one of the pieces of tape. Record your observations as drawings and text below.



Drawing:

Description of what happened:

6. Based on your observations, write a prediction of what you think will happen when two “thrusters” are fired on directly opposite sides of the carton.
7. Try it. Refill the milk carton and open two opposite holes simultaneously.
8. Record your results and indicate why your prediction was correct or not correct.



9. Try different combinations. First make a table of which holes you will open and your prediction of the results. Then record the actual results.

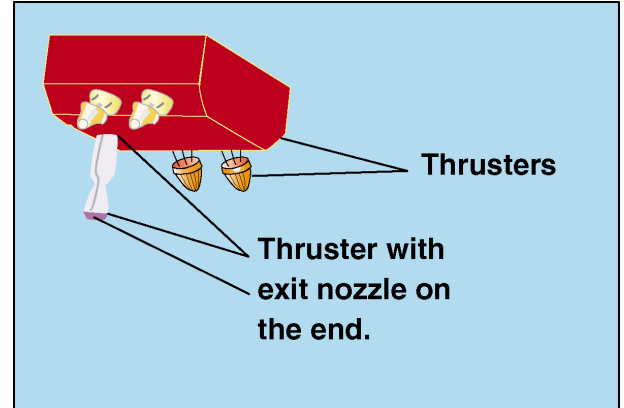
Thrusters open	Predicted Motion	Actual Motion

10. Did the results surprise you? Using Newton's Laws of Motion, explain the motions of the milk carton.
11. Think of a model that would better represent the resulting motion from the engines firing on the spacecraft. Write a description of this model.



## Part 3: The Exit Nozzle

1. Observe the thruster exit nozzles on the diagram. Describe any similarities or differences in the shapes or sizes of the exit nozzles.



2. Why do you think these are different? Do you think the size of the exit nozzle affects the amount of force from the thrusters?

3. Write a question that you can use to investigate the change of thrust resulting from the size of the exit nozzle.

4. Write an if/then hypothesis for your questions. (For example, if the exit nozzle is larger, then the thrust will decrease.) Have the research question and hypothesis approved by your teacher.

5. For this investigation you will use a hair dryer and construction paper to find the answer. Follow the procedure below to answer your question.

6. Roll the construction paper so that it is a long tube. Measure the length of this "exit nozzle" and record it in the table below. Tape it to the hair dryer with electrical tape so that air can only escape if it moves to the end of the tube you made. Use transparent tape to tape the paper to make the tube.

7. Go to an open space with a smooth floor for your test. Take a cotton ball and place it on a "starting line." Use the cool setting on the hair dryer and aim at the cotton ball. Do not allow the hair dryer to cross the imaginary plane that is defined by the starting point. You may continue to aim the dryer at the cotton ball until the cotton ball stops moving. Place a piece of masking tape marked "1" (representing your first trial) on the floor where the cotton ball stopped. Repeat this step two more times. Measure the distances and enter results into the left side of the chart below. Once you have the three distances calculate the average distance by adding the measurements from the three trials and dividing the result by three. Make sure you include the units for your distance measurements.

Long Exit Nozzle	Distance	Short Exit Nozzle	Distance
Length of Exit Nozzle		Length of Exit Nozzle	
Trial 1		Trial 1	
Trial 2		Trial 2	
Trial 3		Trial 3	
Average		Average	



8. Remove the long tube from the hair dryer. Fold a piece of construction paper so that it is a short exit nozzle. Measure the length of this exit nozzle and record it in the chart above. Repeat the same experiment as in step 6, this time recording the results on the right hand side of the chart.
9. What do you think may have caused the differences in the distances for your various trials?
10. List all of the variables that you kept constant in this activity.
11. List all of the variables that you could not keep constant.
12. Be prepared to share your results with the class. Write a conclusion statement that answers your question and uses the evidence that you obtained in the chart. Include if your data supports or refutes your hypothesis.